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DRIVING DYNAMICS SYSTEMS

Model: E65 - 745i

Production Date: 11/2001

Objectives of The Module

After Completing this module, you will be able to:

• Explain how EDC-K influences hydraulic damper operation.

• Identify the correct EDC-K solenoid valve resistance value.

Electronic Damper Control - Continuous (EDC-K)

History

With EDC I in the 1987 E32, BMW AG was the first European manufacturer to introduce a fully automatic electronically adjustable damper system. EDC I provided manual selection during driving between hard, sport and soft damping. Since the market launch, this 2-stage system has been continuously enhanced and evolved into EDC III, it has set the standard for adjustable damper systems in the 5 and 7 Series.

EDC III evaluates the status of the road surface, vehicle load, driving speed and driver's request to automatically activate one of three damper programs: soft, medium or hard. The driver also has the option of selecting a comfort or sports program.

EDC-K is a further development of EDC III. The German abbreviation "K" stands for continuous damping force adjustment. The major change from EDC III is the damper valves and the activation control.
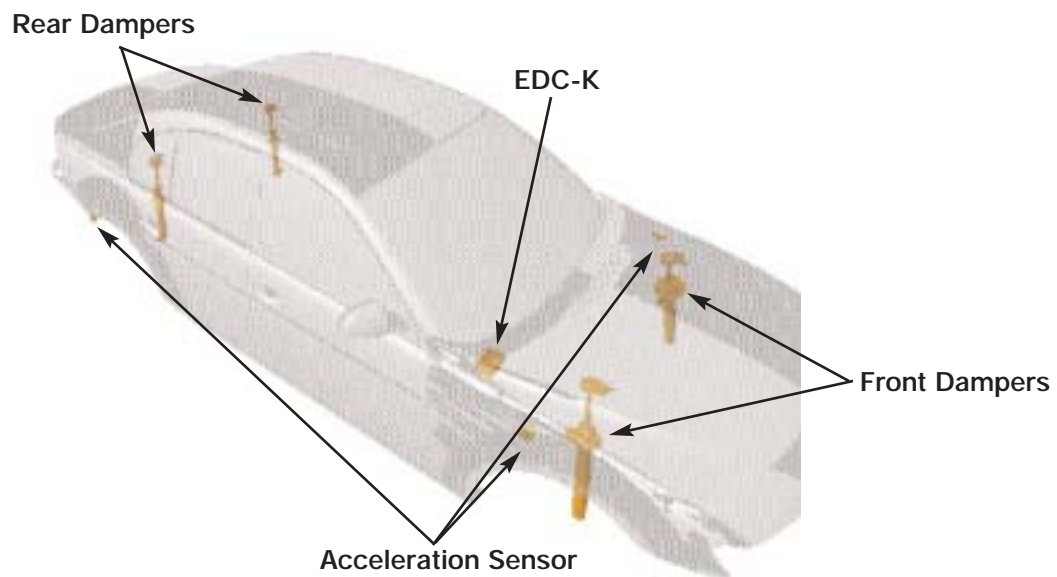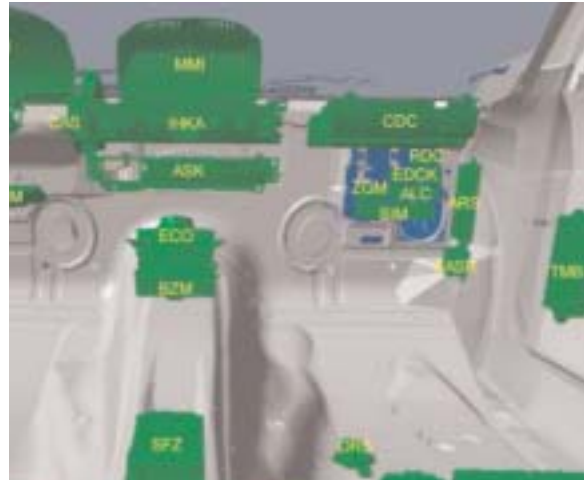

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EDC-K operates with a continuously adjustable valve in each damper. The damping force is adjusted for individual piston speed. The damping force adapts continuously to the low frequency movement of the vehicle body, resulting in a significant increase in driving comfort. The driver has the option to select a comfort or sports setting by using the Controller in the Control Display menu.

The EDC-K system is an option offered under the Adaptive Ride Package.

System Components

EDC-K Control Module: The control module is located in front of the glovebox and is powered by B+, operating within a voltage range of 9 to 16V. In the event of undervoltage, the EDC-K system shuts down to prevent excessive battery draw.

The control module incorporates various control functions that determines the current applied to the damper valves.

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Vertical Acceleration Sensors: The three vertical acceleration sensors provide a varying voltage signal (0.2 - 4.5V) to the control module indicating the speed of body movement. The three sensors are identical and have a measuring range of ± 2.5 g.

The front sensors (1) are mounted on the inside top of the wheel archs and the rear sensor (2) is mounted on the side of the rear wheel arch.
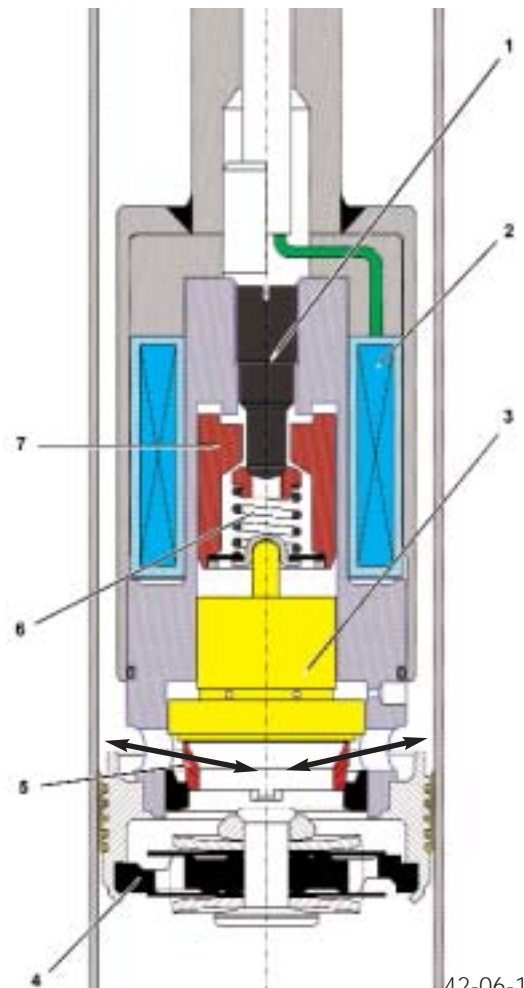

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Electronically Adjustable Dampers: The front and rear axles are equipped with twin tube gas pressurized dampers supplied by Mannesmann Sachs Boge. The fully variable dampers are map controlled and do not have fixed stages.

Each damper incorporates an adjustable proportioning control valve on the piston. The wiring harness for this valve is routed through the hollow piston rod. Damper oil flows through this valve during compression and rebound. The control valve generates a pressure drop between the lower and upper chambers depending on the oil flow volume.

The front and rear axles are separately activated to achieve an optimum response for vibrations in all driving conditions. The valves are deactivated in the event of a control module failure or when the ignition is switched "OFF". The dampers automatically rest in the hardest setting (without power). On vehicles equipped with Dynamic Drive, the spring struts have different valve configurations on the front and rear axles. The dampers are de-energized when the vehicle is stationary. They are energized initially from 5 km/h.

1. Pre-tensioning screw

2. Solenoid coil

3. EDC-K Damper valve

4. Primary valve

5. Floating seat ring

6. Valve spring

7. Armature

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EDC-K Damper Valve - Detail

Infinitely Variable Control Valve: Without power, the maximum hydraulic resistance is set by the screw (1), which pre-tensions the valve spring (6). This is the hardest damper setting, also known as the failsafe (rest) setting.

The valve spring provides maximum tension on the armature (7), which presses down on the EDC-K Damper valve (3). This in turn presses down on the floating seat ring (5) which offers resistance to the oil flow by restricting the orifices (indicated by arrows).

When the solenoid coil (2) is energized by the EDC-K control module, the armature is magnetically pulled upwards against the valve spring tension. The armature will exert less pressure on the EDC-K Damper valve. The tension is decreased on the floating seat ring decreasing the orifice restriction. The oil flow will increase, resulting in softer damping.

When the solenoid coil receives maximum power, the effect will be the lightest tension on the floating seat ring. The orifices are unrestricted, providing the softest damping.

Damper Valve - Hydraulic Details

Compression Stage: The rod and attached piston is forced downwards in the damper cylinder. The oil in the cylinder provides lubrication and resistance to the piston movement (shown to the right).

The oil is forced through the primary valve which pushes the EDC-K Damper valve upwards. The floating seat ring rests at the bottom and the oil will flow through the orifices which control the rate (direction indicated by the arrow).

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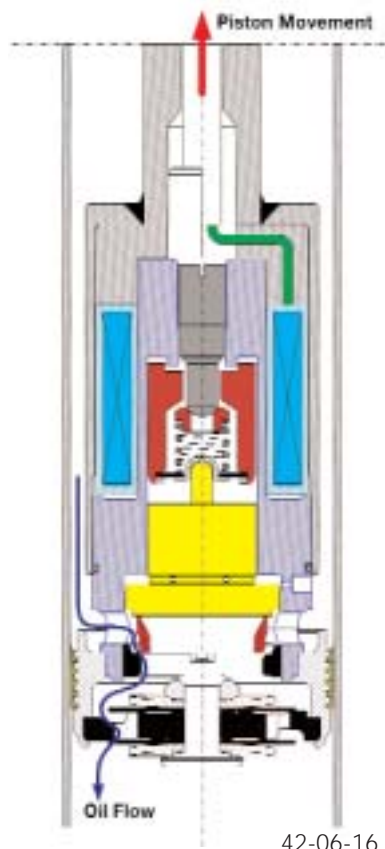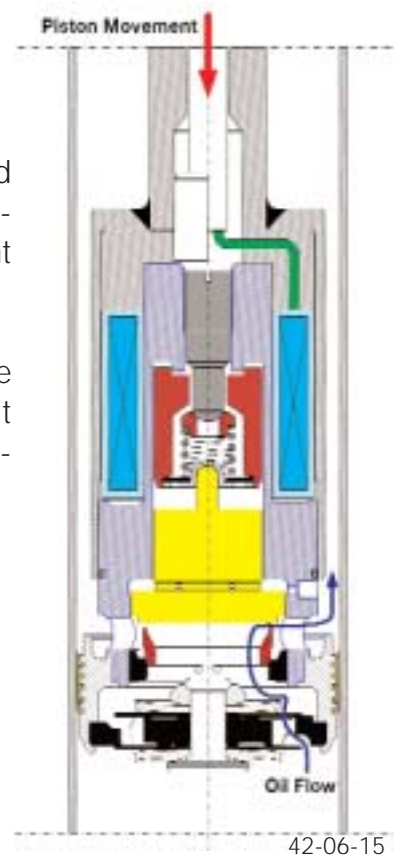
Rebound Stage: The rod and attached piston is forced upwards in the damper cylinder. The oil in the cylinder provides resistance to the piston movement (shown to the left).

The oil will flow through the orifices forcing the floating seat ring up against the EDC-K Damper valve. The oil continues to flow through the primary valve to control the rate (direction indicated by the arrow).

The armature is controlled (electronically) by the EDC-K control module to regulate the EDC-K Damper valve and floating seat ring positions which varies the resistance to oil flow by restricting the orifices.

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Principle of Operation

EDC-K is a microprocessor controlled damper adjusting system. The system consists of mechanical, hydraulic and electrical/electronic subsystems. Acceleration sensors record the driving/road surface conditions and the control module receives the sensor frequency signals for evaluation. The sensor signals are compared with each other for plausibility. The control module logic activates the damper valves according to internal programmed maps to dampen body and wheel movement as needed.

The driver can use the Controller and Control Display menu to select between comfort and sports programs. The system is diagnosable with the DISplus. In the event of sensor faults, the system is switched to a "safe state" by supplying fixed power to the damper valves. In the event of a system failure (no power), the dampers are mechanically sprung to the firmest setting.

The EDC-K function is divided into 3 blocks:

• Control Module
• Sensors and program selection option
• Actuators - 4 electronically adjustable dampers

The input signals for the system are generated by:

Sensor/Switch	Signal	Calculated Variable	Location
Acceleration sensors front axle, rear axle	Vertical acceleration front, rear	Vertical velocity, Compression/rebound travel	Sprint-strut dome FR, FL, RR
Steering angle sensor	Steering angle	Steering angle velocity	SZL
Wheel speed sensors FL/FR	Wheel speed	Driving speed, acceleration/braking	Wheel hubs FL/FR
Program selection	Comfort/sports program		Controller

In addition to the forces calculated in each measured movement, there are vertical, longitudinal, transversal, copy and tolerance control logic.

EDC-K Electronic System Overview
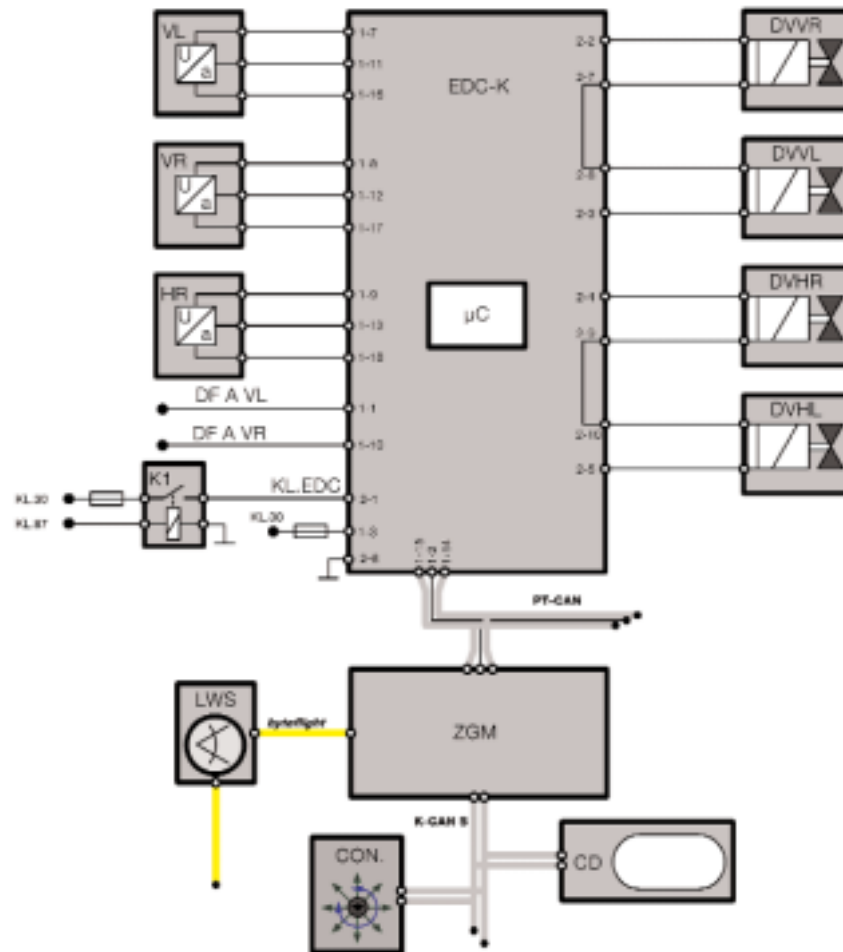
EDC-K Components

VL - Front left acceleration sensor	CD - Control Display
VR - Front right acceleration sensor	DVVR - Damper valve, front right
HR - Rear right accelerator sensor	DVVL - Damper valve, front left
DF A - Front left wheel speed sensor	DVHR - Damper valve, rear right
Con. - Controller	DVHL - Damper valve, rear left
LWS - Steering angle sensor	ZGM - Central gateway module

Vertical Dynamics Control

Vertical Dynamics Control responds to vertical (up/down) body movements based on wheel/body acceleration and speed. A distinction is made between a low frequency body vibration (approx. 1 Hz) and a high frequency wheel vibration (approx. 10 to 15 Hz). Because the body speed cannot be measured, a characteristic value is calculated from the acceleration signals. This value is adapted based on the vehicle speed, frequency ranges and road surfaces.

The higher frequency vibrations of the axle are calculated as the wheel dynamics value based on the wheel speed signal inputs. The value is determined from the irregularities of the wheel rotation when driving over bumps. This control operation takes place separately for both axles.

Longitudinal Dynamics Control

The Longitudinal Dynamics Control responds to acceleration and braking body movements (forward/backward). The vehicle speed signals are monitored by the control module: two direct wheel speed inputs from the DSC control module and three digital inputs from the PT-CAN Bus. Two of the signals on the PT-CAN Bus correspond to the 2 wheel speed signals from DSC and the third signal is the averaged vehicle speed.

The EDC-K control module assesses the plausibility of these signals. A Longitudinal Dynamics value is calculated from the wheel speed signal, which represents the level of acceleration or deceleration. The dampers are adjusted (on both axles) to the harder setting to counter act the longitudinal movement.

Transversal Dynamics Control

The Transversal Dynamics Control responds to transversal movement (dive and squat - front to back roll). This value is calculated from the steering angle sensor and the vehicle speed signals. The onset of "yaw" movement is detected very early from the steering angle sensor signal. A harder damper setting to support the vehicle as it enters a curve is activated at an early stage. The front and rear axles are separately controlled.

Copy Control

The Copy Control function responds to the compression and rebound of the body (encountering bounces on one side of the vehicle) while driving straight ahead. Through comfortable damper tuning, EDC-K responds to one sided unevenness due to the road surface. This prevents a side to side rolling motion while driving straight ahead.

Once vehicle "copying" is detected, a harder damping combination is applied to the front and rear axles. Detection is based on the evaluation of the right and left vertical acceleration signals from the front axle.

Tolerance Adaptation

The damper force is diminished as part of the operating time function. Diminishing damper forces are compensated by current (amperage) reductions which are calculated by the tolerance control. This also individually compensates for mechanical damper wear on each axle.

Control Strategy

All of the dampers are controled simultaneously until a single damper control in particular is required. For stability reasons, the smallest desired output current of the four damper controls (hardest damper setting) is set.

Plausibility Monitoring and Safety Concept

The EDC-K inputs and outputs are checked for plausibility. Depending on the type of fault, restricted operation of the damper control system will occur while a high degree of safety and comfort is maintained.

The control display informs the driver when an EDC-K system fault has occurred. There are two different shutdown options in the event of faults.

- In partial operation, medium damping is set by a fixed current at the front and rear axle valves.

- When the entire system is shut down, the de-energized valves instantly switch (spring loaded) and remain in the "hard damping" setting.

In the event of system faults, the chassis and suspension is set to a safe condition that is acceptable to the driver. The valves, sensors, electric circuits and EDC-K control module are fault monitored.

Notes:

System Faults and Reactions

Malfunction	Fault response
CAN steering angle signal correction Deviation > 10º	Fixed current, fault in memory, gong at end of trip
Acceleration sensors (front, left, right, rear)	Fixed current output for front axle, rear axle Fault in memory, gong at end of trip
Wheel speed front left/right	1) Control operation with replacement sensor 2) Fixed current output for front and rear axles
External voltage supply fault fluctuation (nominal should be 5 V +/- 10%)	Fixed current output for front axle, rear axle Fault in memory, gong at end of trip
Voltage supply to EDC control module between 2 V and 8 V	Valves de-energized, fault in memory, gong During trip
Valve failure	Valves de-energized, fault in memory, gong during trip
Voltage wake up, <2V standing & wake up>7V	Valves de-energized, fault in memory, gong during trip
No vehicle speed via CAN Bus	Fixed current, fault in memory, gong at end of trip
Control module EEPROM faulty	Fixed current, fault in memory
Control module - no alive message from EDC-K	Valves de-energized, fault in memory, gong during trip

CAN Interface

The steering angle value is prepared and is transmitted by the SZL over the CAN Bus. Both of the front wheel speed signals (including the direct DSC wheel speed signal), the vehicle speed reference value and the mileage reading are provided by the DSC control module over the CAN Bus to the EDC-K control module.

Power Supply

Low current supply to the damper valves results in hard damping and a high current results in soft damping. The EDC-K control module determines the setpoints and outputs pulse-width modulated (PWM) signals to the damper valves to regulate the current flow. Current flow limitation is ensured by an overcurrent detection and deactivation. All of the analog inputs are protected by diodes against positive and negative overvoltage. The following analog signals are processed by the EDC-K control module:

• Vehicle supply voltage
• EDC-K switched output voltage
• Damper valve voltage and current

Valve Activation/Output Stage Circuit

The solenoid valves have low resistance, approximately 2.2 ohms per valve at room temperature because high current is needed at a low voltage. The current is set in the 0 to 2 Amps range depending on the desired damping force. The setpoint value will not exceed 2 Amps to avoid valve damage. The solenoid valves are connected in series for each axle and are supplied with a ground (PWM for continuous adjustment) from the EDC-K control module.

Rear Axle EDC-K Valves Series Connection

uC = Microcontroller (EDC-K control module)

PWM = Pulse width modulation (output signal)

DVHR = Right rear damper valve

DVHL = Left rear damper valve
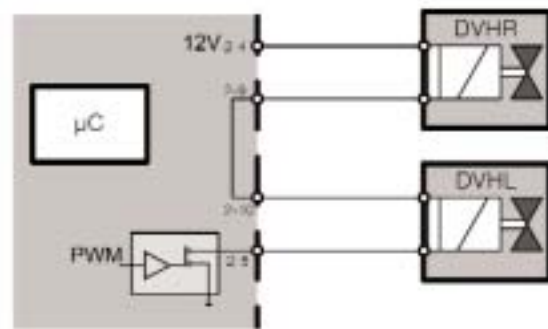
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Controller and Control Display Operation

Sports program: The driver can activate/deactivate the sports program by the Controller in the Control Display menu.

A firmer damping is set when the EDC-K request is set to "SPORT". EDC-K always reverts back to the comfort program each time the engine is restarted.

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Notes:

Workshop Hints

Diagnosis

System monitoring and plausibility: For safety reasons, faults with one damper valve will result in deactivation of all damper valves. Fault detection takes place on each axle. To pin-point which valve is faulty, use the DISplus to measure the resistance of the individual valves (per axle). The resistance of a good valve is 2.2 ohms ±10% at room temperature (20 ºC).

Acceleration sensors: The EDC-K control module does not distinguish individual malfunctions between the sensors. The power supply to the three sensors is connected in parallel in the control module (without isolation). A short circuit in the supply voltage to one of the sensors will also affect the supply to the other sensors.

A maximum of seven different faults can be stored for the acceleration sensors. The coding data will indicate the functions of the control module (vehicle and country specific).

Notes on Service

When the steering angle sensor is removed, the steering wheel must be manually positioned to the straight ahead position and this position re-initialized in the SZL. The steering wheel straight ahead position is permanently monitored while driving.

EDC-K diagnosis detects electronic damper faults on the complete axle only. Mechanical testing of individual dampers can be carried out in the damper test. Mechanical wear causes the dampers to weaken over the service life, therefore a running time memory adapts the damper curves towards a harder setting (over time). Faulty dampers must be replaced together (in pairs) on a single axle. After a replacement, the running time memory for the front or rear axle must be reset with the DISplus.

A 10 Pin Adapter Cable is available to adapt the MFK cables to the EDC-K control module when using the DISplus (Test Plan).

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